NEMATOLOGY.—*Effects of potassium nutrition and amount of inoculum on rate of reproduction of* Meloidogyne incognita. Bakir A. Oteifa, University of Maryland and U. S. Bureau of Plant Industry, on leave from Fouad 1, University, Giza, Egypt. (Communicated by G. Steiner.)

It is well established that nutritional conditions of host plants have a marked influence on development of various bacteria and fungi that parasitize them. As far as can be determined no information is available regarding such influence on development of parasitic nematodes. Godfrey and Oliveira (1932) have shown that the length of time required for reproduction of root-knot nematodes depends on the type of host plant used. Other authors (Chitwood, 1951; Christie, 1949) have indicated that various plant species react differently to the same nematode. In this connection question was raised whether the mineral composition of the host plant affects the reproduction of the nematode infecting it. The present study attempts to ascertain the effect of low, medium and high concentrations of potassium in a host plant upon the production of females and egg masses of the root-knot nematode, *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949, infecting it.[1]

Inoculum used in this experiment was obtained from tomato, *Lycopersicon esculentum* Mill. var. Marglobe. The number of *M. incognita* egg masses contained in a finely chopped sample of roots was counted under a binocular microscope; the corresponding weights of roots containing approximately 50 and 200 egg masses, which were the two levels of inoculum used throughout this experiment, were computed. Glazed, 3-gallon crocks were filled to one-quarter of their capacity with a coarse sand of approximately 8-mesh, on top of which a finer sand of approximately 40-mesh was added so that the pot was about half full. Chopped roots containing the required amount of inoculum in each case were distributed evenly over the surface, after which an additional layer of the finer sand was added to raise the surface to about 2 inches from the top of the crock. Seedlings of lima bean, *Phascolus lunatus* L. var. Henderson that had been germinated in pure quartz sand were transplanted to the crocks when in the 3- or 4-leaf stage.

Composition of nutrient solutions used in the experiment is shown in Table 1. All standard compounds used were of C.P. grade. Immediately after transplanting, each crock received 250 ml of the nutrient solution desired after which additional applications of 400 to 500 ml per crock were added when needed to maintain the proper moisture level. Crocks were flushed weekly with tap water in order to prevent any accumulation of salts.

The experimental design was a randomized complete block with four replications. During the course of the experiment greenhouse temperature varied from 65° to 85°F., with an average temperature of 75°F.

After 70 days the plants had reached maturity and roots of each plant were washed free of sand and rinsed in tap water. After drainage for a few seconds, root weights were recorded and the root-gall index was determined. This index was based on the relative amount of root galling, the root system being classified as follows: 0—no evidence of galling; 1—trace of galling; 2—moderate galling; 3—extensive galling; 4—severe galling. The roots were then finely chopped and the number of females and egg masses in one gram of roots from each plant was counted. Results are given in Table 2. Examination

Table 1.—Composition of Nutrient Solutions Used

Stock solutions	Ml stock/liter of nutrient solution		
	Low	Medium	High
M/1 $Ca(NO_3)_2$	5.0	5.0	5.0
M/1 KNO_3	0.0	5.0	5.0
M/1 $NaNO_3$	5.0	0.0	0.0
M/1 KCl	0.5	0.0	4.0
M/1 NaCl	4.0	4.5	0.5
M/1 $MgSO_4$	2.0	2.0	2.0
M/1 KH_2PO_4	0.0	1.0	1.0
M/1 NaH_2PO_4	1.0	0.0	0.0
A-Z[a]	1.0	1.0	1.0

[a] Micronutrient solution as described by Hoagland and Snyder (1933).

[1] This experiment was carried out in cooperation with the Division of Nematology, Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md.

of the data reveals that the average increase in number of females and egg masses was significant with each increase in concentration of potassium. The mean effect of increase of inoculum increment was likewise highly significant in increasing the number of females and egg masses produced.

Chitwood (1951) has shown that with certain root-attacking nematodes the mean number of females and the mean number of egg masses produced per unit of inoculum were inversely proportional to the amount of inoculum. The present results confirm this (Table 2). For each of the medium and high potassium levels it was found that an increase of egg masses in the inoculum resulted in a corresponding significant decrease in number of mature females as well as a decrease in number of egg masses produced on the test plants. However, in the cases of low potassium level this relationship was only slightly evident. This indicates that the number of egg masses produced per unit of inoculum may be influenced by the amount of potassium available.

Reproductive activities of the nematodes may be limited more by availability of potassium than by amount of root space available to the nematode. When potassium was low the average number of egg masses produced per unit of inoculum was five and the mean root weight per plant was 12 gm. When the level of potassium was medium the mean number of egg masses produced per unit of inoculum was 30, or six times as great as that of the low potassium level, while the average root weight was 27 gm or only slightly more than double the root weight for the low potassium level. When potassium level was high the mean number of egg masses produced per unit of inoculum was 32 and the root weight was 25 gm, indicating that an increase in potassium level from medium to high had little effect on the corresponding root weight and number of egg masses produced per unit inoculum. Thus while root weight increases by a factor of 2 from the low to the medium and high potassium levels the number of egg masses produced per unit inoculum increases by the factor 6.

These data indicate that the maximum number of females which the roots can support under the medium and high potassium levels was in the vicinity of 350 females per gram of root. When roots were infected to that extent the rate of reproduction, which was obtained by dividing the number of egg masses by the number of mature females, was about 0.5. Plants inoculated with 200 egg masses and given the high level of potassium did not support a greater number of females and egg masses than such plants receiving the medium level of potassium. Similar results were evident in the comparison of root gall indices of these plants. Such failure was attributed to the effects of overcrowding. When roots were not heavily infected, as in the case of plants receiving 50 units of inoculum, the number of egg masses per gram of root increased with the increase in potassium level. Rate of reproduction was

TABLE 2.—RELATIONSHIP OF POTASSIUM NUTRITION AND AMOUNT OF INOCULUM TO RATE OF REPRODUCTION OF MELOIDOGYNE INCOGNITA

Potassium levels	Units of inoculum (egg masses)	Mean root-gall index	Mean root weight	Mean number of females			Mean number of egg masses			Mean rate[c] of reproduction
				per gm root	per plant	per unit[a] inoculum	per gm per root	per gm per plant	per unit[b] inoculum	
			gm							
Low	50	3.2	9.2	117	1084	22	20	200	4	0.168
	200	3.8	15.0	246	3675	18	83	1229	6	0.334
Medium	50	2.7	32.5	126	4079	82	54	1665	32	0.428
	200	4.0	23.1	346	8034	40	196	4564	28	0.568
High	50	3.0	21.2	158	3330	67	108	2281	45	0.688
	200	4.0	21.1	361	7668	39	186	3964	20	0.514
LSD[d] .05			5.8	16.9	589.0	10.6	13.7	305.8	5.7	0.173
.01			7.8	23.2	807.8	14.6	18.8	419.3	7.9	0.236

[a] Females per plant divided by egg masses in inoculum.
[b] Egg masses per plant divided by egg masses in inoculum.
[c] Number of egg masses divided by number of mature females.
[d] Least significant differences.

also increased significantly with an increase in the 3 potassium levels: 0.168, 0.428, and 0.688, respectively.

Among plants receiving a relatively low amount of inoculum, rates of reproduction were apparently limited by the amount of potassium available, as indicated by the highly significant differences between treatments. On the other hand, with higher amounts of nematode inoculum an increase in potassium correspondingly increased the rate of reproduction up to a certain point between that produced by the medium and high levels of potassium. Thus it seems that rates of reproduction of nematodes among plants receiving medium and high levels of potassium are correlated with the amount of root available and with competition between nematodes for living space in the roots rather than the amount of potassium available.

SUMMARY

Lima-bean plants grown in sand cultures were inoculated with the root-knot nematode *Meloidogyne incognita*. Three nutrient treatments were employed supplying low, intermediate and high potassium concentrations. Two levels of nematode inoculum were used at rates of 50 and 200 egg masses.

Results of this experiment are:

1. Differences in the number of female nematodes produced on the roots and differences in the rate of their oviposition can be induced by variations in potassium concentrations.

2. Among plants receiving a relatively low amount of inoculum, rates of nematode reproduction were apparently limited by the amount of potassium available.

3. In plants receiving relatively higher inoculum and treated with higher potassium concentrations, rates of reproduction are correlated with the amount of root available and with competition between nematodes for root space rather than with the amount of potassium available.

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ZOOLOGY.—*The last copepodid instar of* Diaptomus sanguineus *Forbes* (*Copepoda*).

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The larval stages of *Diaptomus vulgaris* Schmeil have been described by Grandori (1912) and those of *D. castor* (Jurine) by Dietrich (1915) and Gurney (1931). Nauplii and copepodids of North American diaptomids, however, are almost entirely unknown. Ewers (1930) described the nauplius stages of *D. siciloides* Lilljeborg. C. B. Wilson (1932) described briefly the fifth leg of "young" male and female *D. leptopus* Forbes and the fifth leg of "undeveloped" male and female *D. oregonensis* Lilljeborg, both of these immature forms being apparently the last copepodid stage.

It is the purpose of this paper to describe the last copepodid instar of *D. sanguineus* Forbes and in so doing to supply certain details of the structure of the adult that were not mentioned in Forbes' descriptions (1876, 1882) or by later authors. Since large numbers of the last copepodid stage of both sexes may occur in plankton, along with adults of this and often other species, it is desirable to be able to correlate this immature stage with its adult form.

The specimens of *D. sanguineus* upon which the following description is based were collected from a small ice-covered pond in Weston, Mass., in February and March of 1950 and 1951. The copepods were studied entire and dissected, as stained mounts in balsam, as unstained mounts in glycerin, or